



Exhaust Cold Flow Bench Backpressure Measurement

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. The purpose of this procedure is to measure total exhaust system backpressure and/or backpressure at various locations along the exhaust system using room temperature air. Measured cold flow results are analytically converted to representative equivalent restriction on a running vehicle or engine dynamometer.

1.2 Applicability. This procedure is applicable to any complete exhaust system or portion of an exhaust system. Transient backpressure and steady state backpressure differences are comprehended via the calculation methodology published in SAE 2009-01-1154.

1.3 Remarks. This procedure is an alternative for development testing to test procedure GMW14891, Vehicle Exhaust Backpressure and Induction Restriction Measurement. Backpressure measurements may be used during the exhaust system development process to document total backpressure at various points in the exhaust system. Backpressure measurements may also be used to set fixed restrictions in exhaust systems for ISO 1585 and SAE J1349 or equivalent laboratory dynamometer wide open throttle (WOT) power tests when it is desirable to simulate a vehicle exhaust system backpressure level.

This procedure is comprised of the following:

- Description of the exhaust cold flow test facility
- Description of test input parameters and instructions for their calculation
- Instructions for test setup
- Instructions for test execution
- Instructions for post-test calculations

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ISO 1585 SAE 2009-01-1154 SAE J1349

2.2 GM Standards/Specifications.

GMW14891

2.3 Additional References.

- CG2557, Exhaust Pressure and Flow Calculations Workbook
- H. E. Lennon, Inc., 23920 Freeway Park Drive, Farmington Hills, MI 48335 USA, www.swagelok.com
- McMaster-Carr Supply Company, P.O. Box 94930, Cleveland, OH 44101-4930 USA, www.mcmaster.com
- United Sensor Corporation, 3 Northern Boulevard, Suite 9, Amherst, NH 03031-2326 USA, www.unitedsensorcorp.com

3 Resources

3.1 Facilities. General Motors Milford Proving Ground (MPG) Exhaust and Air Induction Flow Laboratory, or similarly equipped facility, see Appendix A, Figure A1.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Cold Flow Bench. To control desired input flow rates up to 550 g/s and record test results. Mass flow rate accuracy shall be within $\pm 0.4\%$, pressure within $\pm 0.02\%$, and temperature within $\pm 0.3\%$ when measured per ASTM Standards.

3.2.1.1 Console. Contains pressure transducers, computer, and keyboard.

3.2.1.2 Primary. Contains sonic nozzles.

3.2.1.3 Secondary. Contains sonic nozzles. Used when exhaust has dual inlets.

3.2.2 Total Pressure Probes. Kiel probes are utilized to measure total pressure. Total pressure is equal to the dynamic plus static pressure; it is also referred to as stagnation pressure.

3.2.2.1 United Sensor Model KBC-6-W and KBC 12-W probes or equivalent are required. These Kiel probes have a 3.2 mm (0.125 in) diameter venturi and 3.2 mm (0.125 in) diameter stem that is 150 mm or 300 mm (6 or 12 in) long.

3.2.2.2 Kiel probe supply source:

3.2.2.2.1 United Sensor Corporation, 3 Northern Boulevard, Suite 9, Amherst, NH 03031-2326 USA, www.unitedsensorcorp.com.

3.2.3 Nylon Ferrules. Ferrules are required to provide sealing at the fittings located between the Kiel probe, tubing and sonic flow bench.

3.2.3.1 Use ferrule part number: NY-200-SET for 3.2 mm (0.125 in) tubing, or equivalent.

3.2.3.2 Optional ferrule supply source:

3.2.3.2.1 H. E. Lennon, Inc., 23920 Freeway Park Drive, Farmington Hills, MI 48335 USA, www.swagelok.com.

3.2.4 Couplings. Couplings are welded to the exhaust system to provide an attachment for Kiel probes.

3.2.4.1 Use part number: 4464K221 for a 3.2 mm (0.125 in) National Pipe Thread (NPT) half coupling, or equivalent.

3.2.4.2 Optional coupling supply source:

3.2.4.2.1 McMaster-Carr Supply Company, P.O. Box 94930, Cleveland, OH 44101-4930 USA, www.mcmaster.com.

3.2.5 Flanges. Flanges are utilized to connect the inlet end of the exhaust system to the flow bench. Various shapes and bolt patterns are needed to accommodate the variety of exhaust designs.

3.2.6 Gaskets. Various shapes and bolt patterns are utilized to seal all flange configurations.

3.2.7 Duct Tape, Rubber Tape, Mastic, and Clay. Tape, mastic and clay are utilized to stop minor leaks at junctions and plug muffler drain holes.

3.2.8 Adjustable Tables and Stands. The exhaust system is supported by adjustable tables and/or stands during testing.

3.2.9 Overhead Crane. A crane is utilized for positioning the exhaust and exhaust system support.

3.2.10 Flexible Tubing. Flexible tubing is utilized to span the distance between the flow bench air source and the inlet end of the exhaust system.

3.2.11 Miscellaneous Stainless Steel Pipes. Pipes of various diameters are utilized to mate quick connections and exhaust systems to the flow bench. Types include: tee, elbow, straight and straight with diameter transition.

3.2.12 Thermocouple. Measures temperature of air flow (T-Type Specific to MPG Bench).

3.2.13 Compressed Air Reservoir. Volume capable of providing requested pressure for length of test.

3.3 Test Vehicle/Test Piece. Complete or portion of exhaust system with couplings for Kiel probe installation.

3.4 Test Time.

Calendar time: 6 days
Test time: 8 hours
Coordination time: 40 hours

Note: Included in the test hours are the technician resource for exhaust system preparation, setup, and test, and the engineer resource, which includes setup, test, and post-test calculations and data analysis.

3.5 Test Required Information.

3.5.1 Exhaust cold flow rate in grams per second (g/s) corresponding to specification or vehicle exhaust hot flow rate.

3.5.2 Location(s) along exhaust system where pressure is to be measured.

3.6 Personnel/Skills. Technician basic skills needed:

- Ability to weld
- Ability to assemble and disassemble exhaust system and components
- Ability to install Kiel probes into exhaust system and connect to the flow bench
- Trained in basic flow bench operation

4 Procedure

4.1 Preparation. Schedule exhaust cold flow test facility with facility manager.

4.1.1 Test Request. Engineer requesting a test submits a formal test request work ticket. Request must include:

- a. Test date(s)
- b. Exhaust system availability date(s)
- c. Kiel probe measurement locations
- d. Range of cold mass flow rates, typically from 25 g/s to vehicle maximum hot mass flow rate or specification mass flow rate

4.1.2 Pressure Measurement Locations. Every attempt should be made to select pressure measurement locations away from sudden pipe bends or cross sectional area changes. Locations that are at or beyond six (6) times pipe diameter of relatively straight pipe are best. Points of interest typically include:

- Pre-close-coupled catalytic converter(s)
- Post close-coupled catalytic converter(s)
- Pre-under-floor catalytic converter(s)
- Post under-floor catalytic converter(s)
- Pre-resonator
- Post resonator
- Pre Valve(s)
- Post Valve(s)
- Pre-muffler(s)
- Post muffler(s)

4.1.2.1 To save time and resources, only those locations that are key to the exhaust system being developed should be requested.

4.1.2.2 To determine the total exhaust system pressure drop, measurements are only needed prior to the start of the exhaust system.

4.1.3 Coupling Installation. Couplings described in 3.2.4 are to be installed at the locations identified by the requester. Drill holes at requested measurement locations and weld couplings into place.